Sectoral Linkages of Energy in Indian Economy: An empirical evidence

Sanjoy Kumar Dam, Simrit Kaur

Making use of the ‘Input Output Transaction Tables’, this paper analyses the trends in linkages of the Energy sector in the Indian economy over the period 1968-69 to 2003-04. Results show that there has been a gradual rise in the sectoral linkages of this sector. Barring Biomass, all the other Energy sub-sectors exhibit high Forward and Total linkages. In addition, Electricity and Petroleum also have high Backward linkages. In the light of recent energy crisis and the emergence of Energy as a ‘key sector’, an analysis of the same becomes imperative for relevant policy lessons to be drawn.

Keywords: Energy, Input Output model, Backward and Forward linkages, Power of dispersion, Sensitivity of dispersion, Key sector

I Introduction

The Energy content in Indian economy, with its structural shift over the years from primarily an agro-based economy during 1970s to the emergence as dominant services sector during the late 1990s, is expected to have undergone a change. The structural transformation that occurred in the Indian economy over the decades was a consequence of the development process witnessed during different phases of five year plan periods. This has in turn been reflected in the changing sectoral composition of GDP.

Energy is an important input in economic activities. Contribution of Energy services in an economy is marked by a wide variety of issues. The quantum of Energy requirements however, depend upon several macroeconomic aspects, its structural imperatives and direction of flow of Energy into different sectors collectively contributing to the value added in the economy. With the growing changes in the economy, the linkages of Energy sector to different sectors of the economy are therefore, an important aspect of the growth story.

Per capita Energy consumption in India was found to be at a level of 439 kgoe during 2003-04. The projected per capita Energy consumption of India (with @ 8% GDP growth) is expected to be at a level of 1250 kgoe during 2031-32, which will be even less than the world average of 1688 kgoe during 2003. In order to support the projected GDP growth of 8% through 2031-32, India’s primary Energy supply will need to increase by 4 to 5 times and its electricity generation capacity by 6 to 7 times of their 2003-04 levels. Percentage share of Energy mix indicates that coal (currently at 51%) will remain the dominant primary Energy source to be closely followed by Oil (currently at 36%) and Natural Gas (currently at 9%). Considering the resource endowment of the country and various supply options, it is projected that import dependence of Energy in 2031-32 could be as low as 29% and as high as 59% depending upon the emerging Energy mix in the economy. However, on individual basis the import dependence of oil is likely to be the highest at a level of 93% from the current level of over 70% (GOI 2006). Since, presently, over 70% of our crude oil is met through imports, the numbers arising from high oil prices will look positively threatening for the economy. Pricing of Energy products, therefore, constitutes a critical element in the entire Energy value chain.

The plan of the paper is as follows: Section II carries out the theoretical background of growth theories, Input Output framework (IO), methodology and the data sources. The empirical results have been tabulated in section III. Finally, section IV summarizes the results with some comments on policy implications.

II Theoretical considerations

Energy sector in the country has broadly developed under public sector initiative barring the initial few years of independence. The story of growth of Energy sector is therefore, associated with a series of perceived economic and social goals of the country likely to be promoted with the expansion of activities under the public sector. Considering the limited base of entrepreneurship, and large scale investment required for Energy sector in the initial years, Government continued expansion of its role as a development strategy which finally gave central control to the state in the entire value chain of the Energy sector. This trend continues even after the liberalization process of early nineties though with some progressive changes in the policy initiatives which entails involvement of private sector in the Energy sector.

Growth theories

Scholars (Nurkse, 1953; Rosenstein Rodan,1943; Hirschman,1958) argue that linkage analysis and investment decisions in the economy entail discussions into the theoretical explanations given by the proponents of balanced growth theory (BG) and unbalanced growth theory (UBG).

BG explains simultaneous expansion of a large number of industries in all sectors and regions of the economy. As a large number of industries develop simultaneously, each sector generates a market for the other. It further argues that demand for one product is generated by the production of others. However, it acknowledges the fact that BG approach is beyond the resources of most the poor countries besides, BG within a closed economy rather than specialization and
trade contradicts comparative advantage. UBG theorists argue that sufficient resources can not be mobilized by Government to promote widespread, coordinated investments in all industries. Proponents of UBG, specifically Hirschman, believe that UBG is necessary to induce investment decisions, economize on the principal scarce resource, i.e. decision making process and proper sequence of investment decisions. This objective can be attained by following a policy of unbalanced investment. In operational terms, the crucial question is: How to determine the proper sequence of investment decisions in order to create the required amount of imbalance in the right activities? Relevant for this strategy is the concept of ‘linkages’, as discussed by Hirschman (Kaur, 2003; Hazari, 1970)

**Input Output framework**

Input-Output framework is used here to analyze and highlight the linkages between the Energy sector and the rest of the industries in the country. The analysis is based upon the concept of inter sectoral “linkages” which emphasizes the importance of identifying the key sectors which have strong technological linkages with other sectors in order to stimulate economic growth.

Existing literature on economic development generally suggests that sectors with high linkages play an important role in initiating the process of economic development and diversification of industrial structure of the economy and that substantial investment shall be made in these sectors. It is therefore, relevant to assess whether the investment decisions of Energy sectors follow the theoretical explanations as brought out above.

Leontief’s (1966) seminal work on Input-Output framework offers an empirical analysis of production of goods and services in an economy. This in turn seeks to determine what can be produced and quantity of each intermediate product which must be used up in the production process, given the quantity of resources available in the economy and the state of technology. The empirical evidence of the linkages of each of the sub sectors of Energy to the rest of the economy as mentioned subsequently is therefore, based on the model of Leontief Inverse.

**Input Output (IO) Model**

The derivation of both linkages and multipliers is performed through the Input-Output analysis. According to IO theory, output is related to final demand, as given by the usual Input-Output equation.

\[ X = (I-A)^{-1} Y \]

where \( Y \) is the vector of final demand, \( X \) is a vector of total output, \( I \) is the (nxn) identity matrix in an economy identified as having \( n \) productive sectors including Energy sectors . \( A \) is the technology matrix of input output coefficients and \((I-A)^{-1}\) is the inverse matrix, termed as Leontief Inverse matrix.

**Linkages**

The concept of Hirschman linkages are therefore, at play when ongoing activities “induce” more activities to be taken up. As BL effects are related to derived demand, FL effects are related to output utilization. It therefore, follows that by concentrating on the sectors with high forward and backward linkages, the process of industrialization can be enhanced.

**Measurement of linkages**

Hirschman had used linkage indices developed by Rasmussen (1956) to identify the key sectors and study the development strategies. Let \( A = [a_{ij}] \) be a matrix of direct inputs in the usual input – output system and \( B=(I-A)^{-1}=[b_{ij}] \), be associated with Leontief’s inverse matrix. Let \( B_l \) and \( B_f \) be the column and row multipliers of this Leontief Inverse. These are defined as

\[ B_l = \sum_{i=1}^{n} b_{ij} \quad \text{and} \quad B_f = \sum_{j=1}^{n} b_{ij} \quad \text{………(1)} \]

Let \( V \) be the global intensity of the Leontief inverse matrix:

\[ V = \sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \quad \text{………(2)} \]
Rasmussen (1956) has proposed two types of indices drawing on the entries of Leontief inverse matrix.

**Backward Linkage**

The backward linkages also give the *power of dispersion* (Drejer, 2003). The power of dispersion for backward linkages \( BL_j \) is defined as follows:

\[
BL_j = \frac{1}{n} \frac{1/n B_j}{1/n^2 V} = \frac{B_j}{1/n V} \quad \text{(3)}
\]

It measures the effects of an increase in final demand of sector \( j \) on overall output. In other words, it measures the extent to which a unit change in final demand for the product of sector \( j \) causes production increases in all sectors. The interpretation is that if \( BL_j > 1 \), a unit change in final demand in sector \( j \) will generate an above average increase in activity in the economy.

**Forward Linkage**

The forward linkages also give *sensitivity of dispersion* (Drejer, 2003). The index of the sensitivity of dispersion for forward linkage \( FL_i \) is defined as:

\[
FL_i = \frac{1}{n} \frac{1/n B_i}{1/n^2 V} = \frac{B_i}{1/n V} \quad \text{(4)}
\]

It measures the magnitude of output increase in sector \( i \), if the final demand in each sector were to increase by one unit. In other words, it measures the extent to which sector \( i \) is affected by an expansion of one unit in all sectors. For, \( FL_i > 1 \), it is asserted that a unit change in all sectors’ final demand would create an above average increase in sector \( i \).

**Key sector**

A key sector, \( K \), is usually defined as one in which both backward linkages and forward linkages indices are greater than 1. However, Rasmussen - Hirschman notions on linkages and identification of key sectors are not without critical commentary even though the model has extensively served usage for identifying the key sectors of the economy. Three major criticisms as identified by Jones (1976) on the notion are (i) since causality is at the root of Hirschman hypothesis, I-O interdependence as a proxy for linkages involves double counting (ii) index of forward linkages is not symmetrical to that provided by the backward linkages as the concept of unit vector expansion in the final demand for each and every industry in the economy does not seem to be borne by any empirical evidence, and (iii) inclusion of both domestic as well as imported intermediate inputs leaves important implications towards use of cross country comparisons in international comparative studies.

However, rather than engaging into the divergent views about efficacy of methods, these alternative views may be seen as complementary to one another in identifying the economic structure. Rasmussen – Hirschman aforesaid notion is therefore, adopted to index the concept of ranking of the sectors or investments in terms of linkages which otherwise would remain intractable.

**Methodology and Data Sources**

Empirical evidence of this study has been drawn based on the data sources published in Input Output Transaction Tables published by Central Statistical Organization (CSO). The first Input-Output Transaction Table (IOTT) consistent with the National Accounts Statistics (NIS) for the year 1968-69 was published by the CSO, in the publication National Accounts Statistics, 1978. This table was published jointly by the CSO and the Planning Commission. Subsequently, CSO undertook the preparation of IOTTs on regular basis and publishes the same with a gap of every 5 years. IOTT is therefore, available for the country for the years 1968-69, 1973-74, 1978-79, 1983-84, 1989-90, 1993-94, 1998-99 and 2003-04. Based on the data set, forward linkage, backward linkage and key sectors have been derived using formulations discussed above. Further, each of the years for which IO data is available, the linkages of the top three sectors of the economy along with the linkages of the Energy sub sectors have been analyzed.

**III Empirical Evidence**

**Energy market linkages**

The basic objective of this section is to estimate the backward, forward and total linkages of the Energy sector and analyze how these linkages have undergone a change over the period 1968-69 to 2003-04.

**Backward linkages (BLs) hierarchies**

During the reference period the top three sectors of the economy and the Energy sub sectors were found to be as follows:

**Table1: Hierarchical order of BLs of Top three sectors and Energy sub sectors**

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Sector</th>
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<tbody>
<tr>
<td>1968-69</td>
<td>1</td>
<td>Food (other than sugar)</td>
<td>1.342562</td>
</tr>
<tr>
<td>2</td>
<td>Other chemical and chemical products</td>
<td>1.255793</td>
<td></td>
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<td>3</td>
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Energy sub sectors

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A graphical representation of the trends in backward linkage of Energy sector and its sub sectors is given in Figure 1.

**Figure-1(a): Trend in BL of Energy sector**

**Figure-1(b): Trend in BL of Energy sub sectors**
Some observations that emerge from analysis of Table 1 and the Figures 1(a), (b) and (c) are:

1. While food had the highest BL in 1968-69, its relative importance declined over time. Thereafter, manufacturing sectors such as basic metals, Iron and Steel foundries and inorganic chemicals took over and emerged as sectors having high Backward Linkages. However, since the early 1990s, the picture changed and services took over.

2. Even though in absolute terms, BL index for Energy sector has gone up from 4.26 in 1968-69 to 5.15 in 2003-04, the overall share of BL has significantly reduced to less than half at a level of 3.96% from 8.19 % during the same period. The decline in BL index of Energy sector from 4.37 to 3.44 during the period 1993-94 to 1998-99, seems to have been more than offset by its rise to a level of 5.15 during 2003-04. Barring the initial (1968-69 to 1973-74) and the recent (1998-99 to 2003-04) periods of upward shift, the overall BL index does not exhibit any significant change during the intervening period. It is further observed that within the Energy sector, BL index has been predominantly affected by Electricity and Petroleum sub sectors and to some extent by Biomass during the initial period. The other two sub sectors viz. Crude oil and Natural Gas and Coal exhibit weak BL.

3. Amongst the Energy sub sectors, Electricity has emerged as the one with the highest BL index during the entire period barring the initial few years. The relative importance of Electricity has gone up significantly with its BL index having increased from 0.91 to 1.14.

4. Next to Electricity, the Petroleum sub sector has emerged with a relatively high BL varying its index within a band of 0.89 (1989-90) to 1.26 (1973-74). Petroleum has consistently exhibited a strong BL (>1) from the beginning of the period with a marginal dip during 1989-90. However, one interesting feature is that the strength of BL index (even though >1) is on a decline over time.

5. Crude Oil and Natural Gas has been consistently exhibiting a weak BL index. However, a sudden increase of BL index for Crude Oil and Natural Gas is observed during the period 2003-04 to a level of 1.43 as against 0.62 during the previous period 1998-99. Increase of BL index for Crude Oil and Natural Gas as shown in Figures 1(a) to (c) during the period 1998-99 to 2003-04 is attributed to the fact that during the year 2003-04, Natural Gas (NG) sub sector of Energy was separately created in the Input Output table 2003-04 due to significant increase in NG production. During this period, production of NG increased by 20% as compared to about 1% of crude oil. The spurt in BL index for Crude oil and Natural Gas may therefore be attributed to enhanced production activities in NG sub sector.

6. The relative importance of Coal in terms of BL index has been nominal when compared to the other sub sectors viz. Electricity and Petroleum. There appears to be a sudden drop in BL index during 1978-79 for Coal sub sector to a level of 0.30 as against 0.64 during the previous period 1998-99. The country commenced its coal imports effective 1978-79. The percentage production share of coal as primary source of conventional Energy started declining during the period from 54% in 1970-71 to 50% in 2006-07 (Energy Statistics, 2007).

7. Even though the hierarchical position of Biomass has declined during the recent years in the Energy basket, it shows otherwise a steady trend with a marginal increase in BL index during the period 1978-79 to a level of 1.34, when the index was highest amongst all the other sub sectors.

Finally, none of the Energy sub sectors exhibited high BL index to the extent of appearing amongst the top ten sectors during the entire period.

**Forward linkages (FLs) hierarchies**

During the reference period, the top three sectors with high forward linkages of the economy and the forward linkages of Energy sectors were found to be as follows:

| Table 2: Hierarchical order of FLs of Top three sectors and Energy sub sectors |
|-----------------|-----------------|-----------------|-----------------|
| Year | Rank | Sector | Sensitivity of dispersion |
| 1968-69 | 1 | Trade | 3.126098 |
| 2 | Cash Crops | 2.008177 |
| 3 | Electricity | 1.793928 |
| Energy sub sectors | 5 | Coal | 1.610061 |
| 15 | Crude oil and Natural Gas | 1.073762* |
| 27 | Petroleum | 0.858985 |
| 37 | Biomass | 0.727632 |
| Energy sub sectors total Forward Linkage | 6.064369 (11.7)* |

| Year | Rank | Sector | Sensitivity of dispersion |
| 1973-74 | 1 | Trade | 3.472713 |
| 2 | Iron, Steel Foundries | 2.212073 |
| 3 | Electricity | 1.820531 |

| Energy sub sectors |
A graphical representation of the trends in forward linkage of Energy sector and its sub sectors is given in Figure 2.

**Figure-2(a): Trend in FL of Energy sector**

**Figure- 2(b): Trend in FL of Energy sub sectors**

**Figure- 2(c): Trend in FL of Energy sub sectors (indexed)**

Few interesting observations that emerge from Table 2 and Figures 2(a) to (c) above are as follows:
1. Since 1968-69, Trade sector has remained at the top with respect to high FL. Further, the magnitude of this FL increased from 3.12 to 6.54 in 2003-04. Electricity is one of the sectors that had high FL in 1968-69. Further, it continues to be one of the top three sectors with high FL. The FL of Electricity increased from 1.79 in 1968-69 to 4.27 in 2003-04. Cash crops which showed a high FL in the beginning of the period lost its prominence during the subsequent years and were slowly replaced by Iron and Steel foundries of the manufacturing sector during the period up to 1983-84. Thereafter, services came up as one of the top three sectors.

2. FL of Energy sector shows an overall increasing trend. There is a significant difference in magnitude of FL indices of the Energy sector as compared to its corresponding BL indices. During the period, the average share of FL (11.4%) is found to be double that of BL (5.8%). This in turn means that in order to determine the overall linkages of Energy sector within the Input Output framework, the FL characteristics of this sector plays an influential role. In other words, the sensitivity of dispersion of Energy sector with the rest of the economy is significantly higher as compared to its absorption effects. Even though, in absolute terms, FL index of Energy sector has gone up from 6.06 in 1968-69 to 15.4 in 2003-04, the percentage share of FL has however, remained unchanged at a level of around 11% throughout the period with an exception of around 14% during the year 1983-84. Within the Energy sector, Electricity, Crude Oil and Gas followed by Petroleum sub sectors together predominantly influence maintaining the overall upward trend of FL index. Coal and Bio-mass exhibit a declining share in overall composition of FL index for the Energy sector.

3. The relative importance of Electricity has gone up with a significant increase in FL index by about 140 % during the entire period. The major jump of around 79% in the FL index occurred in 1989-90 from a level of 2.63 during the previous block year of 1983-84. However, during 2003-04, a decline of around 24% in FL index was observed from a level of 5.65 in 1998-99. Within the overall FL index of Energy sector, electricity broadly maintains its steady share at a level of around 28%.

4. Coal which started with a high initial FL of 1.61 in 1968-69 (next to Electricity) declined by around 57% to 0.68 in 1978-79 before picking up again to 2.00 during 2003-04. Even though Coal restored its relative importance through a higher FL index, the comparative share of FL within the overall Energy sector declined from around 27% to 13% between the two terminal years. Interestingly, around the same period percentage production share of coal amongst the primary sources of conventional energy came down from 54% to 49%. (Energy Statistics, 2007). The economy also saw the beginning of coal imports from the year 1978-79 onwards.

5. Crude Oil and Natural Gas which started with a high initial FL of 1.07 in 1968-69 next to Coal continued its upward trend during the entire period. Its relative importance through an increasing FL index reaching a level of 4.14 in 2003-04, was associated with the rising share of around 27% in the same year as against 18% in 1968-69. Contrary to Coal, Crude Oil and Natural Gas increased its production share of amongst the primary sources to 12% from 10% while at the same time the rising trend of imports of Crude Oil continued unabated in the economy.

6. In terms of percentage point increase (12 percent point) in FL within the overall Energy sector, Petroleum products were found to be ahead of other sub sectors. Petroleum products, which started with a relatively low initial FL of 0.86 in 1968-69, exhibited a constant upward trend during the entire period. Its relative importance through an increasing FL index reaching a level of 4.01 in 2003-04, was associated with the rising share of around 26% in the same year as against 14% in 1968-69.

7. FL index of Bio-mass which started with a relatively weak link of 0.73 in 1968-69 amongst all the sub sectors continued to decline till 1998-99 with a marginal increase to 0.99 in 2003-04. Its share of FL within the overall Energy sector also declined from 12% in 1968-69 to 6% in 2003-04. This sub sector of Energy has significantly lost its FL impact during the reference period.

Further, on overall basis, the ranking of each of the Energy sub sectors in terms of FL is significantly higher than its corresponding BL indices.

**Total linkages (TLs) hierarchies**

During the reference period, the total linkages of top three sectors and the Energy sectors were found be as follows:

**Table 3: Hierarchical order of TLs of Top three sectors and Energy sub sectors**

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Sector</th>
<th>Total Linkage value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968-69</td>
<td>1</td>
<td>Trade</td>
<td>3.818059</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Iron, Steel Industries and Foundries</td>
<td>2.884342</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Other basic metal industries</td>
<td>2.819317</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Crude oil and Natural Gas</td>
<td>1.746888</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Bio mass</td>
<td>1.717929</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Petroleum</td>
<td>1.903217</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Electricity</td>
<td>2.707505</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Coal</td>
<td>2.249422</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Other Energy sub sectors</td>
<td>10.324961 (9.92)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Total Energy sub sectors</td>
<td></td>
</tr>
</tbody>
</table>

ISSN: 2251-1555

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Some observations –

1. **Trade** has all along dominated its importance in terms of its TL from the beginning of the period and with substantial increase from 3.81 from 1968-69 to 7.19 in 2003-04. However, its percentage share in TL has dropped marginally to 2.7% in 2003-04 as against 3.6% in 1968-69. Manufacturing sectors viz. Iron and Steel Foundries which continued its dominance after
Trade till 1983-84 gave its way to Services sector till 1993-94. Thereafter, again, during 1998-99 Iron and Steel Foundries sector briefly reappeared as one of the top three sectors to be replaced by Petroleum sector in 2003-04. Basic Metals barring the initial two years, did not find much significance during the subsequent periods. 1978-79 onwards, the total linkages borne by Electricity based on its position on backward and forward linkages, is one of the top three in terms of its importance.

2. There is an overall increasing trend in TL for Energy sector. This is mainly influenced by the magnitude of FL of this sector as indicated in course of previous analysis. The magnitude of TL of energy sector has doubled to a level of 20.6 during 2003-04. However, the percentage share of Energy sector within the overall linkages, declined from 9.92% in 1968-69 to 7.92% in 2003-04. A sharp decline (36%) in the TL share was observed during 1989-90 when share of fall in BL (-51%) was significantly more than the fall in FL (-27%).

3. The relative position of Electricity improved from 2.71 in 1968-69 to 5.35 in 2003-04 having shown an increase of around 98% during the reference period. TL share of Electricity during the same period was maintained at an average level of 2.6% showing a marginally downward trend in 2003-04 due to fall in both BL and FL indices. Electricity continued to be top energy sub sector during the entire reference period.

4. Magnitude of TL of Petroleum has more than doubled from a level of 1.9 in 1968-69 to 5.09 in 2003-04 to find a position as the second most important Energy sub sector during the recent period. This significant rise in TL is almost entirely attributed to more than three fold increase in FL index of Petroleum as compared to negligible increase in the corresponding BL index. However, percentage share of TL seems to have marginally fallen from 1.84% in 1968-69 to 1.54% in 2003-04.

5. Coal and Lignite which started its TL index from 2.25 in 1968-69 next to Electricity, dropped significantly to 0.99 in 1978-79 before restoring its position to 2.74 in 2003-04. The drop in TL index in 1978-79 was accompanied by corresponding drop in both BL and FL indices. Drop in BL (-63%) was more significant than the corresponding drop in FL (-36%) physically evidenced by decrease in consumption of coal by almost all the major industries resulting in resorting to imports for the first time in the country. Percentage share of Coal in TL broadly remained at an average level of 2% during the reference period

6. Crude Oil and Natural Gas collectively exhibiting a TL of 5.58 in 2003-04. This even exceeds the TL of Electricity during the same year. However, with increased production activities of Natural Gas, this sector has since emerged as a distinct sector reorganized since 2003-04. When compared with the initial TL of 1.75 in 1968-69, Crude Oil and Natural Gas sector has more than doubled its index. 5

7. The low TL rank of Bio mass at a level of 1.71 in 1968-69 shows a marginal increase to 1.84 in 2003-04. However, percentage share of its TL distinctly declines to little above half from 1.65 % in 1968-69. In other words, relative importance of Bio mass is clearly on a decline during the reference period.

The analysis of TL comprising of absolute BL and FL of Energy sector jointly gives an indication as to how the outputs of Energy sector are distributed (both backward and forward) to other sectors of the domestic industry.

IV Conclusion and Policy Implications

In this paper, an attempt has been made to assess the role of the energy sector in initiating the process of economic development and diversification of the industrial structure of the economy via its linkages. However, while interpreting these results, few limitations of the analysis must be kept in mind. For instance, the Input Output analysis does not take account of the price induced changes in technical coefficients. Further, it assumes that whatever increases in final demand takes place, it will be met by its corresponding increase in the output of the sector. But, if capacity is a constraint, then gestation lag would imply that output increase only gradually, not instantly. Although these effects are not captured by the Input Out put analysis some interesting conclusions emerge. The results reveal that

(i) though Petroleum and Electricity still have high backward linkages (>1), the overall share of energy sector in backward linkages has significantly reduced from over 8% in 1968-69 to a little under 4% in 2003-04

(ii) the forward linkages have generally been high for Electricity, Petroleum, Crude oil, and Coal and Lignite. Further, the percentage share of Energy sector in forward linkages has increased from 10% in 1989-90 to almost 12% in 2003-04. It is also interesting to note that the average share of energy sector over the period 1968-69 to 2003-04, in forward linkages (11.4%) is almost double that of backward linkages (5.8%)

(iii) there is an overall increasing trend of energy sector in total linkages. It is interesting to note that each of five sub sectors of energy has a total linkage greater than 1. However, it is worth mentioning that despite its important position, the percentage share of Energy sector’s TL as a percentage of total TL has reduced from 9.9% 1968-69 to 7.9% in 2003-04.

The results thus reveal that the energy sector has indeed played a very important role in establishing a strong base for the development of India’s industrial structure. This makes it all the more important that this sector with substantial linkages should perform efficiently, more so, in the light of the recent oil price shocks.
Apart from oil price shocks, the energy sector is faced with numerous other challenges. The priorities of each of the sub sectors have been identified in XI plan document (2007–12) of Government of India. The need for a coherent policy framework encompassing on all its sub sectors has also been initiated by Government of India and ‘Integrated Energy Policy’ report (2006). The major concerns expressed in the report are to (i) price the Energy sources in such a way as to provide right incentives for utilizing it efficiently, (ii) create appropriate competitive pressure for enhancing efficiency in the sector, (iii) emphasize on end-use Energy efficiency measures, (iv) provide access to clean and convenient Energy to all sections of society at an affordable price, (v) effectively target the subsidies, (vi) device strategies for promotion of renewable Energy, (vii) intensify R&D efforts for Energy supply options and (vii) take appropriate measures on Energy security.

With the growing evidence of Energy linkages through its various sub sectors and the consequential need for the country for maintaining its sustainable growth, domestic policies are expected to be gradually aligned towards development of this sector. Export orientation of petroleum business during the recent past is an example of the enhanced international linkages, the benefits of which can not be fully captured within the framework of above analysis. Similarly, the other sub sectors of Energy viz. nuclear, hydro power, alternative sources of Energy (wind, solar etc.), non conventional sources of Energy (CTL, GTL, gas hydrates etc.) which are expected to play enhanced roles in deciding the Energy mix also gradually will come into play in linkage analysis in days to come. This is important keeping in view of the recent developments in the areas of climate change and the issues associated with Energy security of the country. Further, development policies towards these sub sectors of Energy will have impacts on the remaining industries which can be observed by the policy makers. In overall view, the country needs to implement a set of measures that bring about improved economic management on mineral and petroleum resources and a policy environment conducive to healthy economic growth. Once these observations on Energy linkages have been made, it is also important to validate these observations with the overall changes in the economy and also establish the changes in terms of intra sectoral dependence. This warrants for a separate analysis, which will be addressed in a further study.

References


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1 In the scheme of classification adopted in the ‘Input Output transaction table’(IOTT) by Government of India, Coal, Crude Oil and Natural Gas have been defined as primary production activity under mining and quarrying sector. Petroleum, Electricity and Biomass have been defined as secondary production activity under manufacturing sector.

2 Energy sector can be categorized into primary as well as secondary sources. Fossil fuel (Coal/Oil/Gas) can be broadly termed as a primary source of Energy. The other alternative sources (Wind/Solar/Biomass/Hydrogen/Nuclear) are used in varied degrees in production of Electricity. Electricity is therefore, known as secondary source of Energy. Energy mix in an economy is essentially a combination of primary and secondary resources which together flow into different sectors as intermediate use and also as final consumption.
Continuation of public sector expansion and dominant role of the Government at a substantial public cost in the business areas where resources can be otherwise mobilized by private sector, has been an area of much debate world over.

Linkages as defined by Bocoum (2000) may be classified as strong, intermediate or weak depending upon the following:
Strong linkages index $\geq 1$
Intermediate $0.9 \leq \text{linkage index} < 1$
Weak linkages index $< 0.9$

This is evident from the rising imports of Crude Oil and changing pattern of Natural Gas usage.